British Society of Dermatological Surgery

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'The role of technology in dermatological surgery'

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Technology driven by innovative theory has been responsible for the legion of advances that took place in medicine throughout the 20th century. No area of medicine has been left untouched, and there are many specialities, such as radiology and histopathology, whose existence is solely dependent on the technology that serves it. From the myriad complexity of an MRI machine to the honest simplicity of a disposable scalpel, technological progression has improved patient care through greater diagnostic accuracy, more specific treatments, and improved safety. Surgery, in particular, has been at the forefront of technological innovation, and many now commonplace surgical practices could hardly have been imagined 40 years ago. In dermatological surgery, treatments such as laser ablation and diagnostic tools like confocal microscopy are pushing the very boundaries of medical technology.

Dermatological surgery is a slightly nebulous entity, encompassing many different treatment modalities, and one *could* simply define it as being whatever a dermatological surgeon does! However, since most dermatological surgeons also employ medical treatments, the term 'dermatological surgery' requires clarification. For the purpose of this essay 'dermatological surgery' will refer to physical as opposed to pharmacological interventions used in the treatment of skin pathology, encompassing treatments with light and temperature, as well as surgical steel. The ‘technology’ used in dermatological surgery will refer primarily to the ‘equipment’ used, and not to the surgical ‘technique’ or received knowledge.

Novel technology in medical practice is rarely genuinely new. With the aid of human invention, new technology emerges from the ashes of old technology; pre-existing equipment is borrowed from other medical specialties or scientific disciplines and modified to perform new tasks. Thus the evolution of technological development is self-propagating: technology begets technology; the human brain is merely the conduit through which this is made possible.

This can be appreciated by observing the historical debt that modern technologies owe to external specialties and disciplines. This lateral transfer of ideas has forged the technology that we use today, and future innovations in dermatological surgery will be shaped by integrating technology from other areas of science with the treatments that are currently available.

Dermatological surgery has a privileged position in the development and use of medical technologies. As a practical specialty it is heavily dependent on new equipment to modify and improve treatments. The skin is a vital organ, but small areas can be compromised without causing risk of life to the patient; thus someone might be willing to undergo an experimental treatment to a lesion in their armpit, but would be less keen if it were on their vena cava. Skin is immediately accessible, so research and energy can focus on the treatment without needing to consider the difficulties of delivery. Furthermore, the visibility of the skin means that the newest technologies are often driven by the cosmetic market and are bought with the currency of human vanity: an almost limitless resource!

This has led to a wide spectrum of treatment modalities within the discipline of dermatological surgery. Media frenzy surrounds the use of lasers, which find their use predominantly in cosmesis, but there are many lasers which can be used in treatments for acne, hirsuitism, photo-aging, and malignancy.[1] Lasers and non-coherent light are used to activate photosensitizing drugs in the skin in photodynamic therapy (PDT), which has proved effective in treating actinic keratoses, BCCs, acne vulgaris, and Bowen's Disease.[2] Whereas laser surgery causes heat damage to tissues, cryosurgery achieves this with extreme cold. Ultrasound can be used to aid the diagnosis and staging of skin tumours, but can also be an effective therapy.[3,4] Other diagnostic tools include dermoscopy, digital photography, and teledermatology, which potentially allows the world-wide network of dermatologists to confer for difficult diagnoses, or simply permits a primary care practitioner to seek expert advice.[5] The case below discusses a referral to a dermatological surgeon. The role of technology in this vignette is discussed afterwards.

Case study

Mr C is a 63 year old gardener referred to the dermatology clinic by his GP with a slow-growing 16mm eroded, pigmented lesion on his jaw, which had been treated with cryosurgery by the GP six months previously as a suspected seborrhoeic wart.

On examination the lesion is located on the angle of the mandible; it is pigmented and nodular with a raised border, it has a pearly appearance with crusting on the surface. Further examination with a dermatoscope reveals no pigment network but *multiple globules of pigment and blue/grey ovoid nests, with thick arborising telangectasia, and areas of ulceration. A diagnosis of pigmented basal cell carcinoma (BCC) is made, and a curette biopsy taken for histological diagnosis.*

Histology confirms the diagnosis of an infiltrative BCC. Due to the infiltrative and recurrent nature of the tumour, Mr C is offered treatment by Mohs micrographic surgery. Clear margins are attained, and the wound is closed with an absorbable suture subcutaneously, and Prolene sutures to appose the wound edges. A follow-up appointment is arranged for three months time.

At follow-up, the wound has healed, but the scar has become raised, firm, red and itchy. The overgrowth extends beyond the shape of the scar, representing an early keloid rather than a hypertrophic scar. The patient is initially offered treatment with steroid impregnated tape (Haelan™) without benefit, and then with course of cryosurgery and intralesional steroids. The keloid resolves over the next six months after three treatments, with good cosmetic result.

Diagnosis with microscopy

In the case above, the dermatological surgeon's diagnosis of the pigmented lesion is assisted by the use of the dermatoscope, which is used to perform surface microscopy, or dermoscopy. Dermoscopy is a non-invasive diagnostic procedure that allows detailed in vivo analysis of skin lesions. The dermatoscope clearly follows the technological evolution described earlier, as it bears many similarities to an otoscope. It is a handheld light source, with a monocular observation window, but rather than having an attachment for a speculum, it has a x10 magnifying lens. Oil is used to eliminate surface light reflection, rendering the stratum corneum transparent. Thus the dermatologist is able to clearly visualize the structures in the epidermis and the superficial dermis not visible with the naked eye.[6] This allows greater analysis of the colours, pigment network, and vascularisation within the lesion.

Surface microscopy of the skin has been around almost as long as microscopes themselves. However it was not until the 1920s that Johann Saphier, a German dermatologist, integrated an internal light source to microscopes used to look at the skin, coining the term 'dermatoskopie'.[7] In 1957, Leon Goldman ('The Godfather of Lasers') advocated the use of dermatoscopes to aid in the differential diagnosis of pigmented lesions.[8] However, dermoscopy did not start getting widespread appreciation until 1971, when Professor Rona MacKie reported a greatly increased sensitivity of malignant melanoma diagnosis by using a desktop microscope.[9] The following decades saw development of the technique in Europe, and the 1990s witnessed the first hand-held dermatoscopes.

Since then, the use of dermatoscopes has become common practice and evidence regarding their effectiveness in diagnosis of skin lesions is growing. Meta-analyses comparing the accuracy of dermatoscopic diagnosis of malignant melanoma with naked eye examination show that dermoscopy is 4-9 times more accurate.[10,11] It is especially useful in diagnosing amelanotic pigmented lesions.[12] Dermoscopy also helps delineate tumours, both melanoma and non-melanoma, thus improving the chances of a complete excision during surgery.[13]

In the future, *in vivo* microscopy of the skin will be able to provide much greater levels of detail by using confocal microscopy. This non-invasive technology selectively collects light from a single point of 'deep' (0.3mm) tissue and scans horizontally, building up a two dimensional picture of the tissue comparable to conventional histopathology microscopy.[14] The images arrive in real time, so detailed cellular diagnosis of tumours could be performed on first presentation, requiring no surgical intervention, nor histology with its time-consuming fixing, sectioning, and staining. Furthermore, affordable hand-held confocal microscopes are in development alongside contrast methods sensitive to confocal microscopy.[15] If this were coupled with a light source that could penetrate 2-3mm, then perhaps in thirty years every dermatological surgeon will be able to obtain their own histological pictures within seconds in an outpatient setting.

Essential surgical equipment

The use of cold surgical steel to treat medical ailments is as old as medicine itself. However, it is highly likely that until the start of the 20th century, surgery was responsible for ending more lives than it saved. This was due to the failure to control the cardinal problems of blood loss, infection, and pain. Although much of the equipment used in the excision of a skin cancer may seem primitive when compared with some of the complex machinery used by surgeons, these primitive tools are actually models of effective simplicity and long-term refinement. The development and evolution of sutures used in modern surgery epitomises this progression.

Techniques for wound closure have been in existence for many thousands of years. In antiquity, the equipment used to perform these closures was based upon the materials at hand, employing flax, animal tendons, and famously, the stiff jaws of the Bengal ant which clamped down on either side of the wound to hold it together. The most commonly used materials during the 19th century were silk threads, which are non-absorbable, and catgut (also used for strings of musical instruments), which is absorbable. One can imagine the horrific risk of infection from using animal intestine for suture material, and it was not until Josef Lister started soaking catgut sutures in carbolic acid that sutures helped to avoid suppurating infections rather than cause them. Sterilisation of catgut sutures allowed them to be left in the body as absorbable sutures with considerably lower risk of infection.[16]

By the 20th century surgical sutures still employed a simple needle and thread design, but the double strand of material at the eye of the needle would cause tissue damage around the wound. This was solved by the current format: clamping the needle around the suture itself, and disposing of the needle after each use. In the 1950s, following the fashion industry (naturally), synthetic polymer threads began to be used. These were not proteinaceous, and therefore promoted less inflammatory tissue reactivity and reduced the probability of infection.[17]

Desirable outcomes in dermatological surgery are rapid healing, avoidance of infection, and a good cosmetic result; these can be optimized by sensible use of sutures. Subcutaneous absorbable sutures avoid the creation of dead space for infection deep in the wound, but these subcutaneous sutures might themselves be a source for infection. New technologies which assist in lowering this risk are antibiotic infiltrated sutures (Vicryl Plus), and studies have shown that they can reduce infection risk in animal models, and reduce post-operative pain (a marker for sub-clinical infection) in humans.[18,19]

During wound healing, the inflammatory process can cause tissue oedema and swelling of the wound. If the sutures are tight and composed of a material with inelastic properties (such as nylon and Prolene), then the swelling may cause ischaemia of the wound edges. Evidence has shown that elastic sutures made from polybutester produce a more cosmetically appealing scar than inelastic sutures like Prolene, as they can stretch and relax with changes in tissue oedema.[20] Since keloid scars have a strong association with wound tension, Mr C might not have developed a keloid scar if an elasticated suture such as polybutester was used instead of Prolene.[21,22]

Future developments of sutures include the use of smart polymers which have 'shape-memory'. These can form self-tying and self-tightening knots upon application of heat. They could be used in sensitive areas where there is little space for manoeuvre, and could also save time in surgery, as knot tying would become much simpler.[23] However, sutures may become redundant entirely if the technology behind staples and glues improves further. Both are much quicker to use and to learn how to use than sutures, but do not yet produce cosmetically favourable results. Glues are especially promising, as they are not only inexpensive and quick to apply, but also provide an antimicrobial barrier to reduce infection risk.[24]

Cryosurgery

The treatment of Mr C's disfiguring scar was cryosurgery. This technology makes use of cold temperatures to treat diseases. The therapeutic mechanism behind cryosurgery takes place in three stages:

1. Heat transfer from the cells to the topical cryogen freezes the cells.

2. Cell damage occurs during the thawing of the cells.

3. Inflammation occurs around the frozen area as a result of the release of intracellular proteins into the tissue.[25]

The technological developments that led to the common availability of cryosurgery were driven by physicists pursuing the creation of liquid gases; this was achieved by Cailletet in France and Picet in Switzerland almost simultaneously in 1877. It was in 1899 that liquid gases were first used therapeutically, by being applied with cotton swabs directly to the skin. Cryosurgery became more readily available after the Second World War with the commercial production of liquid nitrogen dispensers (eg CryAc canisters), which have benefited from space technology in the construction of a non-freezing valve.[26] The advent of cryosurgery probes and hand-held pressure devices during the 1960s, and the safety of liquid nitrogen allowed use of cryosurgery away from main healthcare centres.

The qualities of portability, safety, and ease of use granted to cryosurgery by technological advances make it one of the most frequently performed dermatological surgical procedures in primary care, in the absence of dermatological surgeons themselves. The treatment of simple dermatological pathology with effective therapies in a primary care setting is made possible by up to date technology. This provides good value for money for healthcare providers, and a high degree of satisfaction for the patient, who is saved the need to travel to a secondary care centre. However, the case of Mr C reveals the potential problem this presents.

As technology develops greater complexity, it also adapts to become more usable. It is therefore possible for complex treatments to be performed by practitioners with less experience and skill. While this opens up first class treatments to a larger number of people at a lower price, it also means that many patients might not receive secondary care referrals when appropriate. Mr C's BCC was misdiagnosed as a wart and treated with cryosurgery, when excision would have been more appropriate. Misdiagnosis is common and often forgivable, but the availability and immediacy of the cryosurgery to the GP might have left him disinclined to refer Mr C to a dermatology clinic.

Balancing technology

This raises a key issue with new technologies in dermatological surgery and medicine as a whole. The use of technology in medicine seems almost invariably focused on the disease rather than the patient. It is easy as a doctor to imagine yourself as a swash-buckling hero, stopping at nothing to rid the human body of pathology, but this view is antiquated and now lives on only in ITV3's reruns of 'Doctor in the House'. This paternalistic approach to medicine has given way to a more interpretive or deliberative approach to the patient-doctor relationship.[27]

However, the use of technology by doctors can run contrary to this new philosophy. It is extraordinary and wonderful that all patient information can be available at the press of a button, but there are countless anecdotes of patient frustration at doctors who have consultations with the screen rather than with them.[28,29,30] The role of technology is that of a tool to aid the doctor in the treatment of the patient; the patient is not a tool on which to exercise the technology. Such a maxim might be forgotten by those at the forefront of the research and development of new technologies, who may promote their own equipment and theory to the exclusion of others.

An example of this in dermatological surgery is the extortionate media excitability over laser therapies, which has distorted public expectations about such treatments. Laser therapies have proven effective in many areas of dermatological surgery, but they are not without limitations. Yet patients will often present with the anticipation that they will be given a laser treatment, and that it will be a panacea for their troubles.[31] Such misconceptions are the result of poor media management of emerging technologies, which should have their limitations more honestly shown alongside their benefits.

The future

The ubiquity of technology means that every aspect of the patient pathway can be improved through technological development. Important aims of these improvements include earlier and more accurate diagnosis, the use of technically easier treatments that are quick to administer, reducing hospital visits for patients, reducing pain of procedures, and improving cure rates. Innovations in the future promise monumental improvements in many of these areas.

The process of diagnosis is set to change. Teledermatology may reduce unnecessary visits to hospital and provide nurse-led community-based clinics, as diagnoses can be delivered on the basis of digital photographs and dermoscopic images. UV photography has been shown to identify sun-damaged skin; it might be possible in the future to combine such photographic techniques with immune cancer markers (as used in immunohistochemistry) to detect potentially fatal cancers before they are even visible in the skin.

Using interactive computer programmes to seek patient consent for surgical procedures could decrease consultation times and would also provide electronic documentation of the consent, perhaps reducing medico-legal costs of surgery. Similarly, patient follow-up could be conducted by video-link over the internet. This would drive down costs and save patients unnecessary visits to the hospital.

Teledermatology has been discussed for diagnosis, but teledermatological surgery is a real possibility of the future. Robotic surgery is in its infancy, but decreasing costs and impressive results mean that 'intercontinental dermatological robosurgeon' could be a specialty by 2050. This would help provide isolated areas with expert medical care and permit extreme specialisation within the specialty itself.

Much has been promised about stem cell use, and although it might seem as distant as a 'robosurgeon', already skin culture from a patient's own skin is possible. The implications for this technology in dermatological surgery are profound, and might allow repair of large defects without the need for grafting.

The technological developments of the future will undoubtedly revolutionise the field of dermatological surgery. Common practices in fifty years will be as unrecognisable and extraordinary to us as laser surgery or stem cell grafts would have been to a doctor in 1960. Although the technology will be different, its role will remain constant. It shall be, as it is now, an assistant to the dermatological surgeon: facilitating the care they provide for their patients, improving and simplifying diagnosis, and expanding the wealth of treatments that they are able to offer to the community.

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